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Some Remarks on UV-Radiation at "Reserva Florestal Ducke" Forest Pilot Scheme near Manaus, Amazon.

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Present-day publications concerning UV-radiation measurements under field conditions show an increasing interest in the subject by biology, forestry, industry etc. In consequence, measuring equipment has been pushed forward to a considerable high standard in sensitivity, constancy, durability, and mobility a few years ago.

In our case 2 spray-waterproof Standard Lux Meters II (Dr. Bruno Lange GmbH, Berlin) supplied with four Standard Selenium Photoelements S 60 in pressure-waterproof housings, fixed on 20 m and 40 m rubber flex, were used.

The Standard Lux Meter II, provided with a mirror-backed scale (100 divisions) and a high quality taut suspension band system (to avoid bearing friction), can be switched to either two ranges (0—100 Lux, about 100 foot candles).

Incoming UV-radiation was measured by the use of two special filters in clip-on mount to the Standard Selenium Photoelements S 60.

The UV-1 filter (a black glass filter UG 5, Jenaer Glaswerk Schott & Gen., Mainz) coated on its back with a special fluorescent layer, in order to convert UV-radiation into visible light, is stated by the factory to be useful at wave-lengths from 2000 Å to 3000 Å approximately.

The UV-2 double filter (a double filter combination of UG 2 (d = 2 mm) and BG 23 (d = 1 mm), both by Jenaer Glaswerk Schott & Gen., Mainz) covers the range of 3000 Å to 4000 Å, respectively, with a peak at about 3600 Å.

The UV-1 and UV-2 filter transmission statements made by the factory Dr. Bruno Lange GmbH, Berlin, seemed to be rather general. By the friendly support of Dr. Richard D. Cadle, Head, Chemistry and Microphysics Department, National Institute of Atmospheric Research, Boulder, Colorado, U. S. A., the UV-1 and UV-2 transmissivity graphs were obtained with the Cary-Model 14 spectograph. The results are presented in table 1.

As shown in table 1 the UV-1 filter transmissivity data have some transmission at about 7000Å to 7100 Å, too. This should be put into consideration in respect of future data interpretation.

Table 1. Transmissivity of the UV-1 and UV-2 filters in percent (Cary-model 14 spectograph)

Ä	2900	3000	3100	3200	3300	3400	3500	3600[1]	3700	3800	3900[2]	4000	4100	4200	6700	6800	6900	7000	7100	7200
UV-1	0.01	0.30	0.80	1.45	2.00	2.30	2.65	2.65	2.58	2.40	1.82	1.00	0.38	< 0.10	0.10	0.38	0.96	1.50	1.50	< 0.1
UV-2 (%)	0.00	0.00	< 0.10	1.84	10.00	24.00	36.50	44.60	45.80	35.10	13.20	13.00	0.20	0.20	0.00	0.00	0.00	0.00	—	—

[1]) 3660: 46.0 [2]) 3918: 95.0

Table 2. Prime data of an Acapu and an Andiroba stand in the "Reserva Florestal Ducke" Forest Pilot Scheme.

Species	plot-No	soil composition	root enclosing	seeding date	sprouting percentage	first root shortening	seedlings/m²	mean altitude (m)	date of reading
Andiroba . .	10 A	50% sand 50% "black soil"[1])	bark	2/5/68	87%	18/9/68	130	0.54	10/10/68
Acapu	15 A	50% sand 50% "black soil"[1])	bark	7/6/68	93%	14/8/68	130	0.39	13/11/68

[1]) "black soil" (terra preta) coming from the waste material burning oven of the city of Manaus

Two plots at "Reserva Florestal Ducke" Forest Pilot Scheme (km 26 of the Manaus-Itacoatiara-Road) — an Acapu- and an Andiroba stand — were selected for UV-radiation measurements. Prime data of the two plots are summarized in table 2.

Some supplementary remarks on the different stands are stated as follows:

1.) Acapu — *Vouacapoua pallidor* DUCKE, Leguminosa — acalpineidea, 52 seeds/kg, sprouting range 16—45 days, test of vitality 96 per cent, according to our studies a rather strong light-demander. The Acapu, a tree up to 40 m height, with a remarkable stem diameter at breast height, stocking frequently on soils with a considerable silicate content, is distributed all over Amazon Terra Firme High Rain Forest. The first class wood is used among others for regional shipbuilding.

2.) Andiroba, *Carapa guianensis* AMBL., Meliaceae, 64 seeds/kg, sprouting range 7 to 62 days, test of vitality 91 per cent, according to our studies a 100 per cent light-demander (Reserva Florestal Ducke, Andiroba, planted in 1964 — a) at a shady site, mean altitude 1,82 m (March 1968); b) exposed to full sunlight, mean altitude 4,31 m (March 1968). The Andiroba, present in the entire Amazon region, yields a first class wood of high commercial value.

At km 18 of the Manaus-Itacoatiara-Road UV-radiation was studied on 10 days of the dry season 1968 (July—October), under different weather conditions at minutely intervals between 8,30 a. m. and 4,30 p. m., i. e. a total of 19200 readings.

Some supplementary climatological data were taken from each plot as well as from the open on account of error correction.

1.) Solar radiation (equipment: BELLANI, Davos-Modell 1967) was computed in hourly intervals (potential deviation ± 15—20%) and as the total of the day (potential deviation ± 1%). The instrument was mounted on a steel post 0,50 m above soil surface, considering a typical background (see fig. 2a/2b).

2.) Sunshine (estimated by the observer) was taken in minutely intervals. Observations were subdivided in a) full direct sunlight, b) fair direct sunlight, including hazy conditions, c) no direct sunlight (see fig. 2a/2b).

3.) Cloudiness (observer's estimation) was calculated in five-minute intervals. The following code was in use: a) absolutely no clouds in the sky, b) clouds, 1 to 3 tenth, c) clouds, 4 to 6 tenth, d) clouds, 7 to 9 tenth, e) sky completely covered with clouds (see fig. 2a/2b).

4.) Windvelocity (equipment: cup anemometer No. 1440, W. Lambrecht, Göttingen) was measured in hourly intervals 0,50 m above the ground. During storms a high sensitive current meter (equipment: current meter No. 640, W. Lambrecht, Göttingen) was additionally put into operation (see fig. 1a/1b).

5.) Precipitation (equipment: recording rain gauge No. 1509, W. Lambrecht, Göttingen) was read off recorder charts (see fig. 2a/2b).

6.) Maximum air temperature (equipment: 10 maximum thermometers DIN 58654, calibrated, W. Lambrecht, Göttingen) was taken for the plots by 7 maximum thermometers (deviation ± 0,7° C) and in the open by the three maximum thermometers (deviation ± 0,1° C) in thirty minutes intervals. Readings were done at the plots 0,05 m above the ground of the stand, and in the open 0,05 m above bare soil surface, each about 3,00 m off from the plots (see fig. 1a/1b).

7.) Relative air humidity (instrumentation: motor aspired pschychrometer M 22, Karl Weiss, Gießen) was taken at the plots 0,20 m above the ground of the stand,

about 0,05 m—0,10 m below the canopy, and in the open 0,20 m above bare soil surface, 3,00 m off from the plots, in thirty-minutes intervals (see fig. 1a/1b). Considering the climatic elements 4 to 7, stated above, some more or less detailed information should be given about their hold on the Standard Selenium Photoelements, on the UV-filters as well as on the UV-radiation readings of the two plots below the canopies.

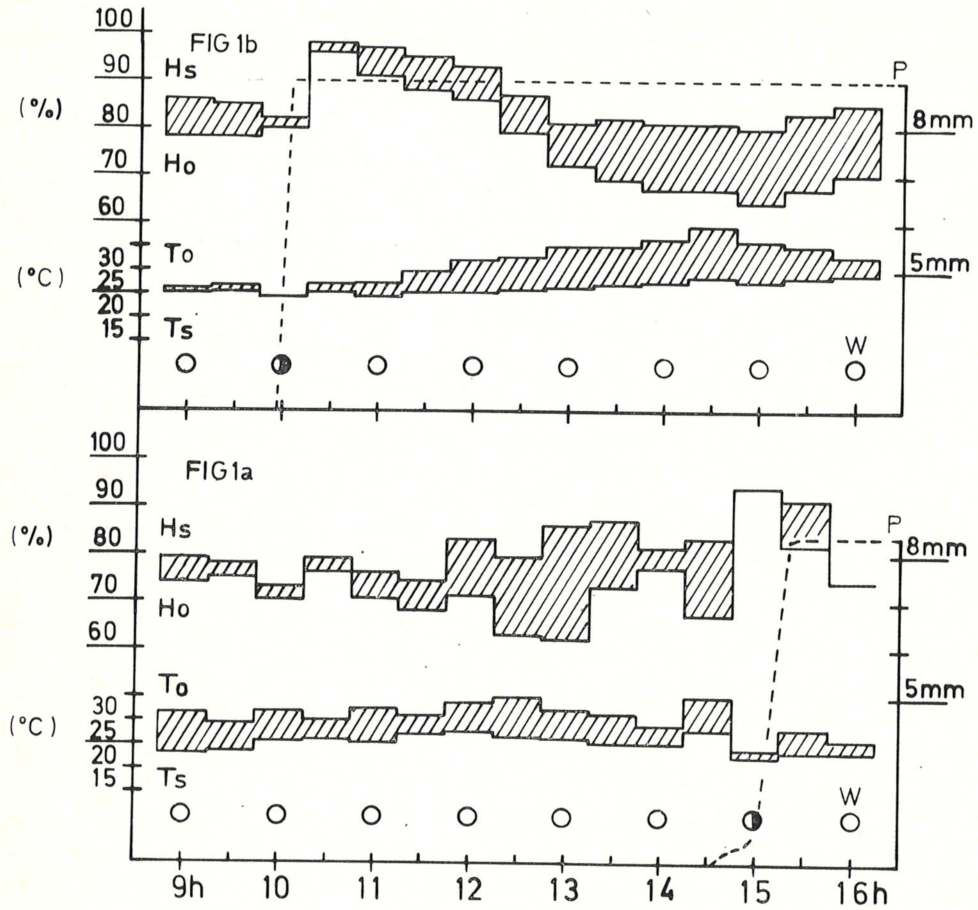

Fig. 1a/1b: "Diurnal march" of maximum air temperature (stand = Ts, open = To), relative air humidity (stand = Hs, open = Ho), precipitation (P) and mean wind velocity (W) at the Acapu (1a—4/10/68) and Andiroba (1b—2/10/68) plot.

as to 4.) In general the near to ground wind field had no considerable influence on UV-radiation measurements at the plots on account of a low wind velocity. But the situation changed completely before or during heavy downpours. Both, the Acapu as well as the Andiroba stand, each covered with an equal number of sets (see tab. 2), showed remarkable differences in UV-radiation with regard to their individual plant characteristics. The relative UV-radiation input of the Acapu stand was computed to

be much higher than that of the Andiroba plot, which, under undisturbed conditions bearing a very closed canopy already, became an even more effective shelter under wind influence. Any wind impact on photoelements or filters was not observed at all.

as to 5.) Precipitation had some influence on radiation input of the two stands, too. While the Andiroba plot was hardly touched at all, the Acapu stand showed a considerable disturbance of the crown projection area compared with normal conditions. Twice, during a heavy storm, rain water entered between the UV-filter and the photoelement. As the water was removed from the backside of the filter at once, no discrepancy in UV-readings was perceived.

as to 6.) Maximum air temperature in both stands was at every time well below the 50° C level, the critical temperature for selenium photoelements under permanent load. The same is valid for the open. But the heat absorption of the black painted housings of the photoelements had to be given our fullest consideration. To avoid damage by overheating, the houses were coated with a high reflectant aluminium foil. In spite of the extremely high albedo of the foil, UV-radiation observations obviously did not transgress the tolerance of the readings.

as to 7.) Some informations about evaporated water between the UV-filter and the photoelement were taken from relative humidity data. Although occasionally water traces occurred, a considerable impact on the UV-readings was not proved in any case.

For UV-radiation readings two Standard Selenium Photoelements (filters UV-1 and UV-2) mounted on tripods have been exposed horizontally in the open, about 0,20 m above the canopies of the stands. On the other hand, two Standard Selenium Photoelements (filters UV-1 and UV-2) were partly dug into the ground of the stands and exposed horizontally, too. After 2 days' experimentation on shadelight and sunflecks, the photoelements were installed and recorded remarkably representative data of both sides under undisturbed conditions.

Out of the 10 days UV-radiation reading the "diurnal march" of UV-radiation input to canopies and grounds of the Acapu (4. 10. 68) and Andiroba-plot (2. 10. 68) were chosen for proof of two typical occurences during the considerably wet dry-season 1968. Data are given in figure 2a/2b.

On account of their decisive influence on UV-radiation, the data of solar radiation, sunshine pattern and cloudiness (according to the numbers 1 to 3 of the supplementary climatological data) are represented in figure 2a and 2b.

as to 1.) Solar radiation readings of high quality ($\triangle \pm 1\%$) were taken for comparative daily energy input calculation of the two stands only, as the hourly totals were of a very low standard ($\triangle \pm 15$—20%). But to give a general idea of radiation input, these data have been pointed out, too. Unfortunately, a conversion factor of UV-units to energy units has not been found up to now.

as to 2.) and 3.) Sunshine pattern and cloudiness were systematically estimated corresponding to UV-radiation observations. From a methodical point of view, both observations should always be taken at the same time, although individual readings suffer considerably from lack of objectivity. With regard to a nine tenth overcast, UV-radiation input of the two plots may be taken as "full direct sunlight", "fair direct sunlight" as well as "no direct sunlight". On the other hand, considering a two tenth overcast, the same effect is liable to occur. For further information see ANDERSON (1964), Evans (1956), GRUBB, WHITMORE (1967) etc.

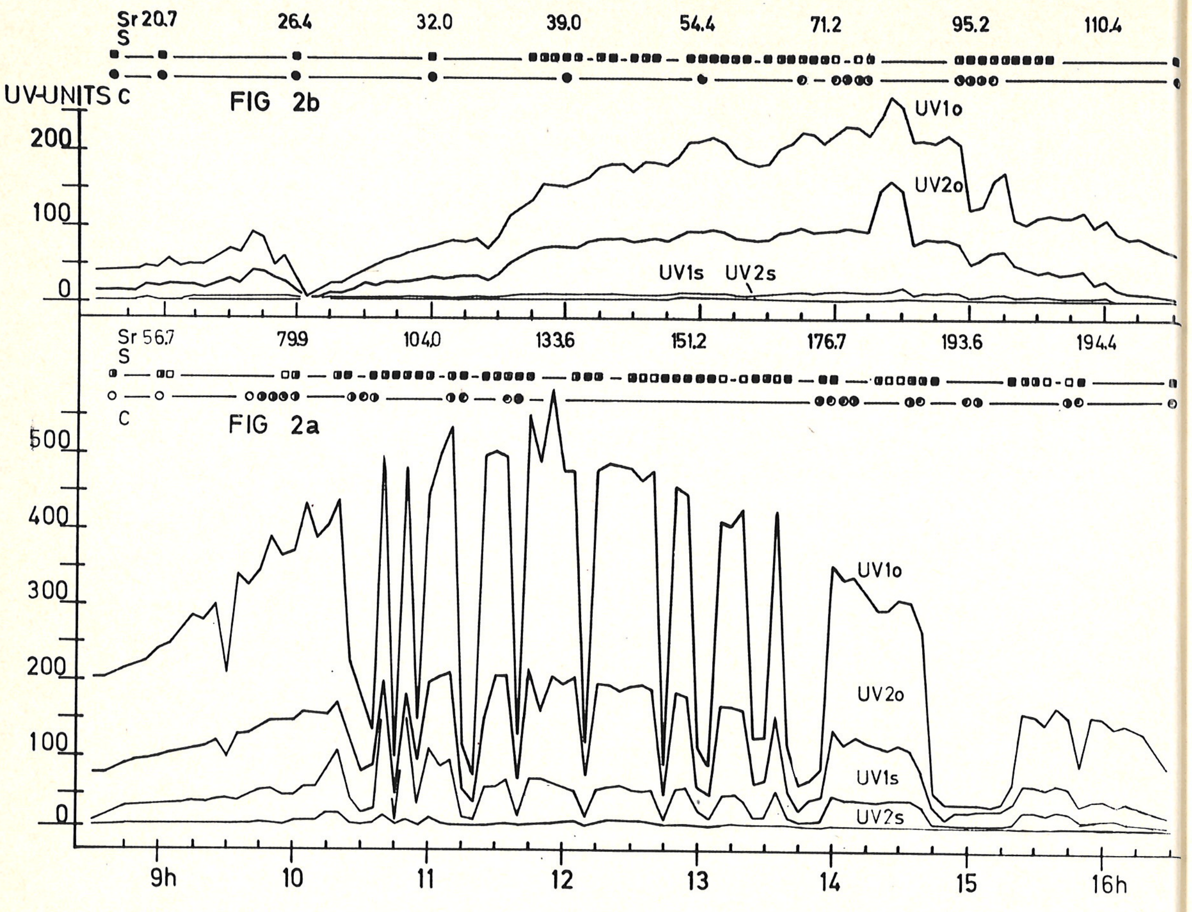

Fig. 2a/2b: "Diurnal march" of UV-1 (open)-, UV-1 (stand)-, UV-2 (open)-, UV-2 (stand)-radiation, solar radiation (Sr), sunshine (S) and cloudiness (C) of the Acapu (2a — 4/10/68) and Andiroba (2b — 2/10/68) plot.

Total UV-radiation input below the canopies of the stands was computed in % of total incoming UV-radiation in the open (ratio A — UV-1 (stand / UV-1 (open) in %; Ratio B — UV-2 (stand) / UV-2 (open) in %).

As the ratio of the readings inside/outside (in %) was useful in the calculation of the canopy transmittance factor as well as the radiation input factor of the ground of the stand, the former being of interest as far as energy input to leaf mass is concerned, the latter estimating potential influence on seedlings and ground vegetation. The half-hourly and hourly means of both relations (A and B) were computed for the Acapu and Andiroba stand as well. Data are presented in table 3.

Table 3. Ratios of UV-1 (stand) / UV-1 (open) = A and UV-2 (stand) / UV-2 (stand) / UV-2 (open) = B in half-hourly and hourly means for the Acapu and Andiroba stand.

	ACAPU A		ACAPU B		ANDIROBA A		ANDIROBA B	
	UV-1 (stand)/UV-1 (open) (%) mean (30 min)	mean (60 min)	UV-2 (stand)/UV-2 (open) (%) mean (30 min)	mean (60 min)	UV-1 (stand)/UV-1 (open) (%) mean (30 min)	mean (60 min)	UV-2 (stand)/UV-2 (open) (%) mean (30 min)	mean (60 min)
	12.5		5.4		1.3		0.0	
9 h	11.4		5.7		1.5		0.0	
	11.0	11.3	6.1	5.1	2.3	1.9	0.0	0.0
10 h	16.0		2.6		5.2		0.0	
	20.9	19.4	4.9	3.7	3.5	4.3	0.0	0.0
11 h	14.9		4.3		2.1		0.0	
	11.7	13.3	4.6	4.5	1.8	2.0	0.0	0.0
12 h	12.4		4.5		2.9		0.0	
	14.2	10.8	4.4	4.5	2.5	2.7	0.1	0.04
13 h	12.0		4.3		1.6		0.2	
	10.3	11.8	4.6	4.4	0.9	1.2	0.3	0.26
14 h	11.7		4.7		1.5		0.5	
	11.4	11.6	5.1	4.9	0.8	1.1	1.1	0.80
15 h	12.3		5.3		0.1		0.3	
	13.6	12.2	5.2	5.0	0.5	0.3	0.1	0.0
16 h	11.4		4.8		0.2		0.0	
	11.2	11.3	4.5	4.6	0.2	0.2	0.0	0.0

For comparison, the 5 day means of the ratios A and B for each site were also calculated and summarized in table 4.

Table 4. Ratios of UV-1 (stand) / UV-1 (open) = A and UV-2 (stand) / UV-2 (open) = B in 5 day means for the Acapu and Andiroba stand

	A (%)	B (%)	A : B (%)
Species	5 day mean	5 day mean	5 day mean
Acapu	13.0	1.9	about 7 times
Andiroba	4.6	0.3	about 15 times
Acapu/Andiroba	about 2.5 times	about 6.5 times	

As shown in table 3 and 4, there is a clear difference in UV-transmission of the canopies of the two stands on account of the density pattern and the leaf-size spectrum, although mean standard height is fairly equal (see table 2).

In addition to table 4 the 5 day mean of the ratios A (UV-1 (stand) / UV-1 (open)); B (UV-2 (stand) / UV-2 (open)); C (UV-2 (open) / UV-1 (open)) and D (UV-2 (stand) / UV-1 (stand)) was taken for each plot under different weather conditions as a) full direct sunlight, b) sun well behind clouds at about 5 tenth overcast and c) downpours at sky completely covered. The results are shown in table 5.

Table 5. Ratios of A, B, C, D, (see text) under the different weather conditions a, b, c, (see text).

	a)		b)		c)		
	Acapu	Andiroba	Acapu	Andiroba	Acapu	Andiroba	
A	12.6	5.4	11.2	5.1	11.2	0.0	5 day mean (%)
B	1.8	0.4	1.8	0.003	0.0	0.0	5 day mean (%)
C	40.4	40.2	45.2	44.5	50.0	41.8	5 day mean (%)
D	4.7	1.6	8.6	0.002	0.0	0.0	5 day mean (%)

According to tables 3—5, the Acapu and Andiroba stand show considerable differences in UV-1 and UV-2 radiation input. Taking into account, that soil moisture was at all times well below wilting point because of sprinkling, and that root competition was avoided by enclosing the root systems of the seedlings in cylindric shaped barks (diam. = 0,06 m, length = 0,20 m), incoming UV-radiation as well as IR-radiation seem to be rather important eco-factors in plant-growth at the survey plots.

Our future work on UV-radiation as an ecological factor in tropical forest will be intensified. Reaction analyses of individual species in any state of growth as well as of high or degraded forest complexes will be studied all over the year to communicate some detailed understanding of dynamics and pattern of forest regeneration in the Amazon Basin.

Resumo

Na Reserva Florestal Ducke no Km 26 da Estrada Manaus-Itacoatiara foi medida com dois aparelhos Lux Meter a radiação, usando-se quatro elementos de selênio. Sôbre êsses elementos foram colocados Filtros ultravioletos (UV-1 e UV-2). Essas medidas foram realizadas em dias de verão de 1968 de minuto a minuto das 8,30 às 16,30 h num total de 19200 leituras. Estas foram feitas na clareira e em canteiros com mudas de Acapú e Andiroba respectivamente sob condições climáticas variáveis (sol claro, cortina de vapor, parcial e totalmente nublado e com tempo chuvoso), êsses resultados podem ser observados nas tabelas.

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